The role of nutrients in cyanobacterial blooms in a shallow reservoir

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Certificate of original authorship

I certify that the work in this thesis has not previously been submitted for a degree nor has it been submitted as part of requirements for a degree except as fully acknowledged within the text.

I also certify that the thesis has been written by me. Any help that I have received in my research work and the preparation of the thesis itself has been acknowledged. In addition, I certify that all information sources and literature used are indicated in the thesis.

Signature Date

Acknowledgments

I have been looking forward to writing this section for several months now as I felt that it would mark the completion of my thesis and I should save it up for the very end when every graph would have been plotted, every chapter written and every section typeset. Having now reached this point and looking back, I feel grateful to have had the opportunity to do a PhD thesis in the first place.

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Abstract

This thesis examines potential causes for algal and cyanobacterial blooms in Grahamstown Dam, a shallow mesotrophic drinking water reservoir in coastal NSW, Australia. The objective was to understand the role of nitrogen and phosphorus in algal and cyanobacterial growth and to elucidate other chemical and physical processes that may enhance cyanobacterial growth in the lake.

Algal and cyanobacterial nutrient limitation was examined on different spatial and temporal scales in in situ assays. Other aspects that have been found to promote cyanobacteria, i.e. high irradiance levels as may occur during thermal stratification and trace metal nutrient additions, were investigated in situ. The effects of different nutrient supply ratios and different light climates on growth rate and yield of the prominent potentially toxic cyanobacterium *Anabaena circinalis* were tested in laboratory experiments. Different aspects of nutrient release from the sediments were examined under conditions that may occur during persistent thermal stratification, i.e. bottom water anoxia. Further experiments elucidated the influence of organic substrate on microbially mediated nutrient release process in the sediments.

Phytoplankton biomass and most individual genera were colimited by nitrogen and phosphorus. Further, the growth response of potentially toxic cyanobacteria lagged behind the response of most other phytoplankton. Many algae responded with increased growth to the combination of high irradiance and nutrient enrichment. The response of potentially toxic cyanobacteria was inconclusive. Trace metal nutrient additions enhanced the growth of one potentially toxic cyanobacterium and most non toxic genera. Nitrogen concentration and not nutrient ratio or phosphorus concentration determined yield of *A. circinalis*. This effect was increased by higher irradiance levels. Growth rates were enhanced

by high irradiance and high N concentration. The sediments were a source of N under oxic and anoxic conditions. Small amounts of phosphorus were released during anoxia only when the availability of dissolved organic C was improved, indicating microbiological activity as the cause of phosphorus release. Moreover, iron and phosphorus release was not caused by the same processes in the sediments.

These findings imply that a pulse of nutrients is not likely to lead to cyanobacterial blooms in Grahamstown Dam but it cannot be excluded that a gradual increase in nutrient load would not. Persistent thermal stratification may increase the risk of cyanobacterial growth by providing increased levels of nitrogen and an improved light climate. Unexpected results, such as insensitivity of cyanobacteria to nutrient enrichment, phytoplankton colimitation and decoupling of iron and phosphorus cycling in the sediments suggest that further research on shallow coastal lakes would be useful.